



CRUSER • NEWS

Consortium for Robotics and Unmanned Systems Education and Research

FROM TECHNICAL TO ETHICAL...FROM CONCEPT GENERATION TO EXPERIMENTATION

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Joint Interagency Field Experimentation (JIFX) 13-4 Completed

by Gerald Scott, NPS Research Associate and Lisa Trawick, CRUSER Operations Manager

Since 2002, NPS field experimentation events have been conducted such that maximum innovation and collaboration are encouraged between DoD, government agencies, industry, universities, and in which military, first responder, and non-governmental participation and feedback are utilized for effectiveness, affordability, and feasibility of future capabilities. The success of the NPS field experimentation events led the Office of the Secretary of Defense to request a version of these events focused on the needs of the Unified Combatant Commands (COCOMs). A cooperative team including the Naval Postgraduate School, National Defense University, and representation from each COCOM and the Department of Homeland Security participate in the Joint Interagency Field Experimentation (JIFX) at NPS's facilities at Camp Roberts, CA. Industry and civilian academic researchers are invited to attend based on the submission of a white paper describing areas of research and applicability DoD and government needs. Government employees can attend as observers, but are still required to register in advance.



JIFX has evolved to fulfill these primary purposes:

- Providing the COCOM and subordinate forces the knowledge and understanding to better define requirements of current and future mission sets
- Exploring the viability of new technologies as potential solutions for current and future capability gaps
- Identifying key attributes and parameters associated with emerging technologies
- Creating an environment that encourages collaboration and seeds innovation
- Examining multi-use capabilities for homeland security, stabilization, reconstruction and disaster relief/humanitarian assistance
- Providing a unique, interdisciplinary graduate education experience for NPS students and research opportunities for NPS faculty

JIFX 13-4 was held last week and included several different planned experiments in the unmanned systems/robotics thread. One of the many benefits of the JIFX environment is the adhoc experiments that arise in a collaborative environment, leading to additional innovation. These are the planned experiments for the unmanned systems/robotics thread.

- Tactical Operations for Multiple Swarm UAVs by Dr Timothy Chung, NPS
- <20lb Multi-Band (UHF/X/L-band) SlimSAR by Joseph Campagna, Artemis Inc.
- Micro SAR for Group 1 UAS (Puma) by Dr. Adam MacDonald, AeroVironment
- InstantEye - Versatile Low Cost Tactical SUAS by Dr. Richard Guiler, Physical Sciences Inc.
- Small Unmanned Aircraft System (SUAS)/Unattended Ground Sensor (UGS) Auto-Launch Demonstration by Dr. John Appleby, DHS S&T/BMD
- LightSpeed - Secure Communications by Greg Hays, Torrey Pines Logic
- Situational Awareness wrist-device with flexible display by Eric Forsythe, Army Research Lab
- UAV Platform - Cybersecurity by Gabriel Raia, CS-Solutions
- Common controller for unmanned systems by Nicholas Stroumtsos, SSC PAC
- Graph Algorithm for Wireless Relay Planning by Dr. Raymond Moberly, SDSU

The next JIFX is planned for 4-7 November. The call for white papers will be sent out when it is open and the JIFX website contains all the information needed to submit an experiment or request to attend as an observer.

JIFX website:

<http://www.nps.edu/Academics/Schools/GSOIS/Departments/IS/Research/FX/JIFX/JIFX.html>

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[HTTP://CRUSER.NPS.EDU](http://CRUSER.NPS.EDU)

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Director's Corner

There are two great educational opportunities in September starting with the NWDC/CRUSER sponsored Warfare Innovation Workshop which will kick-off our third innovation thread "Distributing Future Naval Air and Surface Force Capabilities." In addition to the workshop CRUSER will be hosting a facilitated debate as part of our Robo-Ethics Continuing Education Series.

Steve Iatrou, CRUSER Director of Education

USNA Internship in the Center for Autonomous Vehicle Research (CAVR)

by MIDN Curtis Khol

This summer NPS researchers in the Center for Autonomous Vehicle Research (CAVR) hosted me to conduct sea trials with the SeaFox unmanned surface vessel (USV). This project objectively compared the performance of three different adaptive speed controllers developed in LT Mike Hurban's thesis (MSME, March 2012). The operational objective of this research is to develop and implement a controller that enables an autonomous USV to follow desired speed commands under a variety of environmental and/or vessel loading conditions. The ability to adapt to new or rapidly changing operational environments will eventually allow USVs to perform novel, tactical missions without human supervision.

The SeaFox operates in displacement mode at low speeds and planing mode at high speeds, but exhibits a rapid, speed-dependent transition between these modes. Due to the nonlinear dynamics, which occur during transition, conventional linear control methods are limited to only small portions of the entire operating envelope. To address these challenges, three adaptive control architectures were implemented onboard of SeaFox hardware: Proportional-Integral-Derivative (PID) control-with-gain scheduling, Model Reference Adaptive Control (MRAC), and L1 adaptive control. The PID controller regulates errors to zero and selects different PID gains based the vessel's current velocity and throttle setting. The MRAC and L1 controllers, however, automatically adjust for uncertain parameters as the SeaFox travels through the water. Prior to implementing each controller on the SeaFox, MIDN Khol used computer simulations to verify that control algorithms implemented onboard achieve the same performance as predicted by the theory and demonstrated in LT Hurban's Simulink-based algorithms. Additionally, MIDN Khol constructed design and analysis aids to help researchers tune the new adaptive controllers while at sea. These tools provided a near real-time analysis of each sea trial, which facilitated tuning of the controller to maximize performance.

An L1 controller had never been tested on the NPS SeaFox prior to this summer, even though it achieved the best speed-following performance in LT Hurban's simulations. This project completed implementation of the L1 controller to allow a truly objective performance comparison between the three adaptive control architectures—in the same location and under the same test conditions. Initial testing was conducted on Lake San Antonio to provide a smooth water environment under ideal conditions. Finally, all three controllers were tested on Monterey Bay in order to test the robustness of each controller under realistic ocean wind and wave conditions. The results of this project will be presented at the Oceans 2013 MTS/IEEE conference in San Diego this September.

CRUSER Robo-Ethics Continuing Education Series (RECES) 2013

The next event in the CRUSER Robo-Ethics Continuing Education Series (RECES) will be a facilitated debate on Monday afternoon 23 September 2013 in Glasgow 102 beginning at 1300. NPS Defense Analysis professor Dr. Bradley J. Strawser will moderate this discussion of the question: Does the future of unmanned and autonomous weapons pose greater potential ethical dangers or greater potential ethical rewards? Panelists include ethicist Dr. Heather Roff and journalist Mr. Joshua Foust. All are welcome to join the discussion – no registration required!

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Additional information: <http://cruser.nps.edu>

Navy Lab hosts underwater robotics competition

by Ashley Nekoui, SSC Pacific Public Affairs Office, ashley.nekoui@navy.mil

There was plenty of excitement from student teams during the 16th annual RoboSub Competition, held at Space and Naval Warfare Systems Center Pacific's (SSC Pacific) Transducer Evaluation Center (TRANSDEC) pool, July 23-28.

RoboSub, co-sponsored by the Office of Naval Research and Association for Unmanned Vehicle Systems International Foundation, hosted 30 national and international collegiate teams, in addition to five high school teams and the first middle school team to participate in the competition.

The goal of this competition is to advance the development of autonomous underwater vehicles (AUVs) by challenging a new generation of engineers to perform realistic missions in an underwater environment. The event also fosters ties between young engineers and organizations developing AUV technologies.

"Inspiring and encouraging today's youth to pursue careers in science, technology, engineering, and math (STEM) is important to us at SSC Pacific, and we're happy to host the RoboSub Competition for the 12th year in a row," said Capt. Joe Beel, SSC Pacific commanding officer. "RoboSub is a platform for students around the world to highlight their abilities and aptitude, while fostering teamwork, communication and creativity, all important attributes for a STEM professional. SSC Pacific has a strong education outreach program in the local community, and RoboSub is a great opportunity for us to invite the public to visit the lab and meet with the students and our engineers."

"License to Dive" was the theme of this year's RoboSub competition and the goal was for an AUV to demonstrate its autonomy by completing an underwater "License to Dive" mission. The requirements for the underwater task were established, and the teams were judged on their ability to complete the mission.

Volunteer divers, including Navy divers stationed at SSC Pacific, launched the AUVs into the water at the TRANSDEC facility. SSC Pacific's TRANSDEC pool is a one-of-a-kind facility that simulates an ocean of water and provides ideal conditions for research. Built in 1963, the pool measures 300 feet by 200 feet with a depth of 38 feet.

Winners of the RoboSub Competition were announced Sunday, with first place awarded to Cornell University. Second and third place were awarded to the University of Florida and Far Eastern Federal University, respectively.

Councilwoman Sherri Lightner, City of San Diego Council president pro-tem, attended the RoboSub competition; she

highlighted the importance of STEM during her visit with the students.

"Whether it be maritime robotics or any other high-tech field, a STEM education and experiences such as today's competition are what will help you reach your goals," said Lightner. "I note that many of you are in high school or attend college and are well on your way toward a STEM education and career," she said. "I challenge you to give back to this community of people who have inspired and supported you, and help bring along the next generation of scientists and engineers behind you. You are already leaders by being here today."



SAN DIEGO -- David Biancolin from the University of Toronto works in the test pool at this year's RoboSub Competition, held July 23-28, 2013 at Space and Naval Warfare Systems Center Pacific's Transducer Evaluation Center pool. RoboSub, co-sponsored by the Office of Naval Research and the Association for Unmanned Vehicle Systems International Foundation, provides an opportunity for student teams from around the world to design and build autonomous underwater vehicles capable of completing realistic missions. (DoD photo by Alan Antczak, U.S. Navy/ Released)

SAN DIEGO -- U.S. Navy divers stationed at Space and Naval Warfare Systems Center Pacific watch as China's Harbin Engineering University vehicle passes through the first gate during a test run in SSC Pacific's Transducer Evaluation Center pool during the RoboSub Competition on July 25, 2013, hosted by SSC Pacific and co-sponsored by the Office of Naval Research and Association for Unmanned Vehicle Systems International. Photo Credit: Alan Antczak



Upcoming CRUSER Monthly Meetings

Wed 21 Aug 2013, 1200-1250 (PDT)

Root 242, VTC, or dial-in 831-656-6681

Wed 11 Sept 2013, 1200-1250 (PDT)

Root 242, VTC, or dial-in 831-656-6681

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Short articles of 300-500 words for CRUSER News are always welcome - cruser@nps.edu

- Unmanned Systems/Robotics research
- New Program/Systems/Projects
- Other aspect of Unmanned Systems/Robotics

STUDENT CORNER

STUDENT: LT Kyungho Kim, USN

TITLE: INTEGRATING COORDINATED PATH FOLLOWING ALGORITHMS TO MITIGATE THE LOSS OF COMMUNICATION AMONG MULTIPLE UAVs

CURRICULUM: INFORMATION TECHNOLOGY MANAGEMENT

FULL THESIS: <http://calhoun.nps.edu/public/handle/10945/32848>

ABSTRACT: The thesis addresses the problem of mid-air collision avoidance among multiple Autonomous Unmanned Aerial Vehicles (UAVs) capable of communicating their flight states across a time-varying communication network. The UAVs capabilities to (a) follow a given path and to (b) exchange and coordinate their relative position while on the path are considered the key factors enabling the time-critical coordination that in turn guarantees the safety of flight. The thesis is based on the key results of the recently developed concept of Coordinated Path Following (CPF) for multiple autonomous agents. While the path-following methodology is adapted without modification, the information exchange over the time-varying communication network and its impact on the performance of coordination was analyzed in a comparative study. The impact of the time-varying information flow is represented by the loss of link ratio, which is the ratio of time without information exchange to the nominal timeframe of communication in a given bidirectional network. The particular coordination metrics utilized are the coordination error (difference between the relative positions of UAVs on the paths) and the Euclidian distance between the UAVs (space separation). On the other hand, the control effort necessary to achieve the desired coordination is represented by the level and variation of the commanded velocity profile. The particular goal of the numerical study was to understand the amount of control effort required to achieve the desired separation of UAVs capable of exchanging a minimum number of parameters over a degrading communication network.

**Does your DoD Organization have a potential thesis topic for NPS Students?
Contact us at CRUSER@nps.edu**

Robotics Team claims seventh straight championship

by Joel Anderson, Development Director Kansas State University, Office of Research and Sponsored Programs, jdanderson@ksu.edu

Kansas State University's Robotics Team won its seventh straight championship at the student robotics competition offered at the recent annual international meeting of the American Society of Agricultural and Biological Engineers in Kansas City, Mo.

The university has never lost the competition since its inauguration in 2007.

"I think the students' interest in robotics and their positive experience obtained through participating in the activities have kept them motivated year after year," said Naiqian Zhang, professor of biological and agricultural engineering and team adviser. "The positive encouragement and strong support from the department of biological and agricultural engineering and the College of Engineering also were an important factor for their continued success."

For the competition, the team had to design robots that could go into a hay field -- simulated by toilet paper rolls on a 8-by-8-foot board -- and pick up "bales" colored red, blue and green, then stack them at three corners of the board, respectively. Points were awarded for speed, accuracy and elegance of design. Zhang said the students worked on their robots for several months prior to the competition. <http://www.k-state.edu/media/newsreleases/jul13/robotics73013.html>

We (the ubiquitous we, not just Kansas) have a need that ranges from platforms collecting data to farmers actually needing cost affordable opportunities to use information from a knowledge management standpoint. Collecting the data is only a small piece of the pie. Applications cross a

multitude of need but a challenge is to be able to show the farmers their fields to better understand how to enhance their yields, reduce waste, be environmentally sound, support their profitability margins and feed an exploding global population. As I said, just from a practical standpoint, the need to feed a world population projected to exceed 9 billion people by 2050, we must maximize the use, development and innovative approaches to technology and information that can enhance food production. This hybrid blend of technology, data and knowledge management will become increasingly significant assets, cross multiple domains, and will meet increasing applications for dual use technologies. Today a farmer, tomorrow a squad leader, the next day a weather forecaster and immediately following a first responder. Geospatial intelligence and PED are no longer in the sole domain of particular entities, but are becoming increasingly available and their utility profound across every common denominator from the macro to the micro within government, industry, academia and a growing civil market place.

For a quick snapshot on the population issue take a look at:

<http://www.kstate.edu/media/newsreleases/mar10/feedworld30510.html>

2050 is not too far down the road and we need to maximize our collective efforts to bridge the ubiquitous valley of death so that we can enable effective access into an existing and future information sphere while maximizing the ability to collect, assess information and adaptively and flexibly utilize data on individual, specific and modifiable terms to the need at hand.

The article "A Computationally Efficient Approach to Trajectory Management for Coordinated Aerial Surveillance" by CRUSER members NPS professors Vladimir Dobrohodov, Kevin Jones, and Isaac Kaminer with University of Pennsylvania professors James Keller, Dinesh Thakur, Mihail Pivtoraiko, Jean Gallier, and Vijay Kumar is included in the inaugural issue of the journal Unmanned Systems.

Manuscripts of Unmanned Systems can be downloaded free at the journal's website: <http://www.worldscientific.com/us/>